§11. Analysis of Radial Electric Field in LHD towards Improved Confinement

Yokoyama, M., Ida, K., Sanuki, H., Itoh, K., Narihara, K., Tanaka, K., Kawahata, K., Ohyabu, N., LHD Experimental Group

The radial electric field (Er) properties have been examined for LHD to indicate the guidance towards improved confinement associated with Er transition and bifurcation. The Er is obtained based on the ambipolar condition with the neoclassical flux calculated by the analytical formulae. This approach is appropriate for the purpose of this paper to clarify Er properties in a wide range of temperature and density in a more tranceparent way. The original model magnetic field in Ref.[1] is extended to include sideband helicities to be applicable to the configuration control in LHD. Some of other equilibrium parameters are directly given from three dimensional equilibrium calculations based on experimentally measured plasma profiles.

The calculated Er is compared with experimentally measured Er to check the validity of this approach for LHD and to make wide range calculations meaningful. The experimentally observed tendency that Er becomes positive as the density (n) is decreased is qualitatively well reproduced. The threshold density for the transition from ion root to electron root is also reproduced based on calculations, which is again in qualitatively good agreement with experimental results.

Based on this assurance of this approach for LHD, wide range calculations have been performed to clarify the parameter region of interest. This is the region where Er transition and bifurcation is possible as already experimentally confirmed in CHS[2]. As n is increased, this region shifts towards higher temperature (T) (especially Te) region, which is consistent with above mentioned experimental result for the transition from ion root to electron root below the threshold density. This tendency clarified with calculations has also been experimentally confirmed based on the following two experimental results. One is that the positive Er is observed by increasing temperatures even for higher n. Another is that the negative Er is enhanced for higher n. The dependence of the region of interest on other plasma parameters are also examined such as the magnetic field strength (B) and gradients of temperatures and density. This systematic calculation can give comprehensive understandings of experimentally observed tendencies of Er properties, which can give the appropriate guidance towards improved confinement. The results have shown that the parameter region of interest is shifted to a lower T (especially Te) region by reducing B and increasing Te for lower n. This situation can be experimentally tested in a controlled manner at the edge region in LHD where the pedestal-type temperature gradient is formed[3] with lower n. It is interesting to examine how electron root behaves at the plasma edge associated with the edge pedestal and how it affects the plasma confinement property.

In this paper, Er properties are examined at a certain radius for a particular discharge as an example. The analysis for different radius should also be performed to examine the possibility of Er domain interface formation and to realize electron root also in the plasma core region in LHD.

References

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